Bias correction of regional climate models over Croatian region – influence on statistical measures of temperature and precipitation

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Outline

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  - Standard deviation / Coefficient of variation
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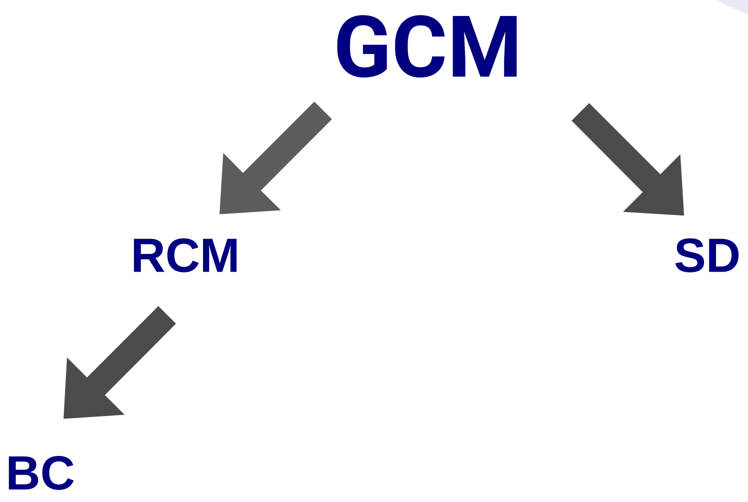
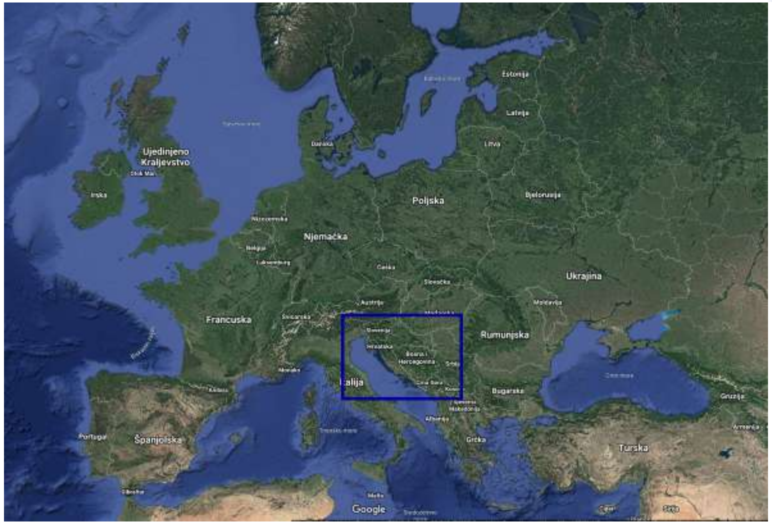
Introduction

- Global climate model (GCM) – simulations of climate system
- Coarse spatial resolution 100-400 km
- Downscaling
  - Dynamical – regional climate model (RCM)
  - Statistical (SD)
- Large scale climate connected to local climate
- Bias – deviation of modeled values from measurements
  - Limited spatial resolution, simplified physics and thermodynamics, numerical schemes, ...
- Using climate simulations in hydrological models or impact studies – require almost no bias → **bias correction**



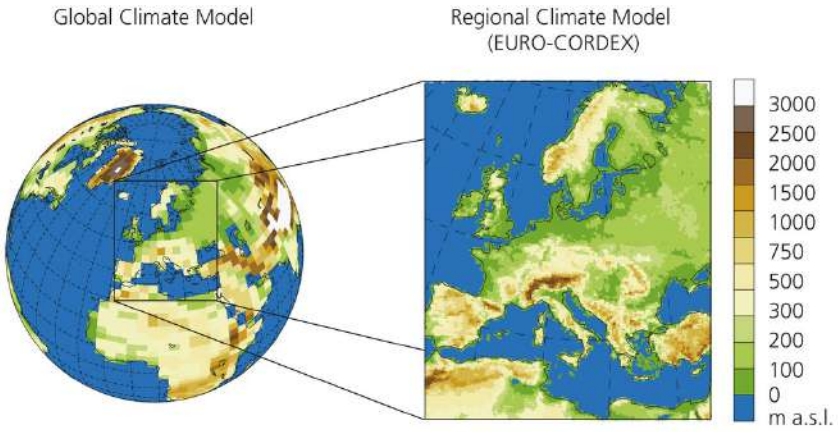
Data 1/2

- Monthly precipitation sum and mean monthly air temperature – seasonally (DJF, MAM, JJA, SON)
- Domain 42°-47°N x 12°-21°E
- Calibration 1971 – 1990
- Validation 1991 – 2004
- Measurements
  - **E-OBS** 19.0e version, 0.1° x 0.1° resolution



Data 2/2

- Regional climate models - 12.5 km x 12.5 km
  - **RegCM4**
  - **CLM**
  - **RCA4**
  - Boundary conditions from global climate models:
    - **MPI-ESM**
    - **CNRM-CM5**
    - **HadGEM2-ES**
    - **EC_EARTH**
  - Bilinear interpolation to E-OBS grid
- 12 members ensemble – ensemble mean



Source: https://www.nccs.admin.ch

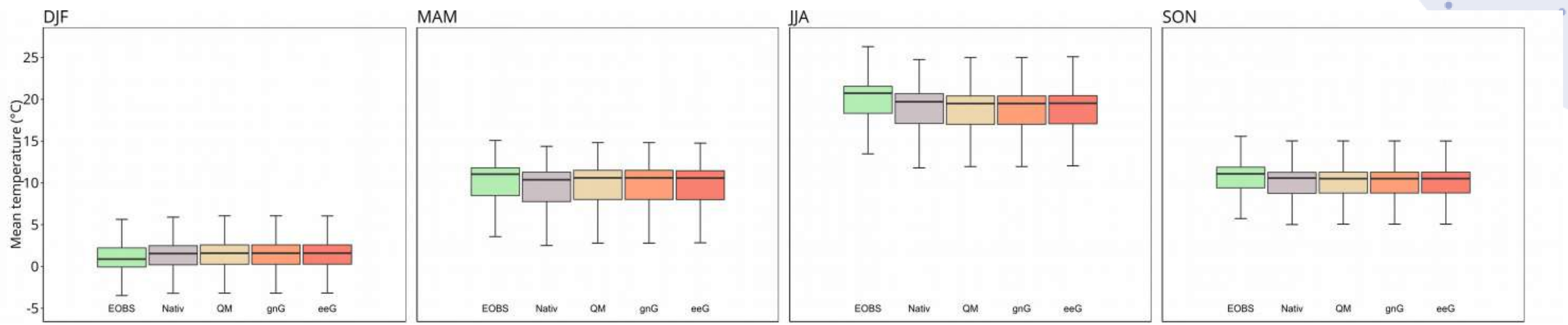
Methods

- Model Output Statistics MOS
- Univariate
  - Quantile mapping (**QM**)
    - Gamma – precipitation
    - Normal - temperature
  - Linear transform function
- Bivariate

$$\Phi(x, y) = P(X \leqslant x, Y \leqslant y) = (1-p_w)H_y(y) + p_w C(F(x), G(y))$$

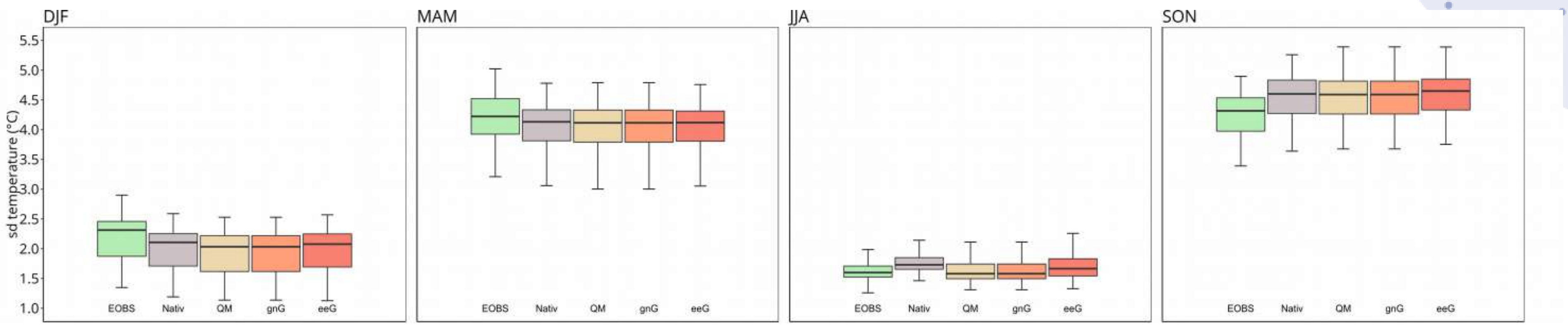
    - *C* Gauss copula
    - *F(x)* precipitation distribution
    - *G(y)* temperature distribution
    - p_w probability for rainy month
    - $H_y(y)$ temperature distribution
  - Given T
  - **gnG** – **g**amma, **n**ormal, **G**auss
  - **eeG** – **e**mpirical, **e**mpirical, **G**auss
- Statistical measures
  - Mean
  - Standard deviation / Coefficient of variation
  - Skewness
  - Correlation coefficient
- Boxplot – all grid points in domain

Results – temperature MEAN



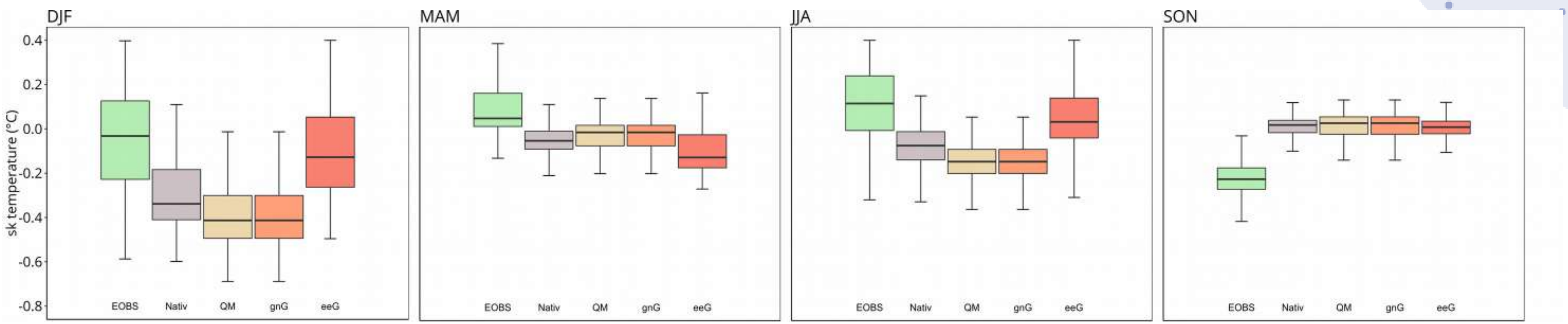
- Native models ensemble close to measurements – small bias (between -0.29°C and 1.04°C)
- Winter warm bias, all other seasons cold bias
- The largest deviation from observations during summer
- Given T – QM and gnG same results
- Corrections rather small
- eeG method slightly worse than QM and gnG
- Best performance of all methods in MAM

Results – temperature STANDARD DEVIATION



- Bias in standard deviation – warm in JJA and SON and colder in DJF and MAM
- eeG performs better only in winter, while in summer it enlarges interquartile range (IQR)
- During winter, QM and gnG enlarge bias
- In intermediate seasons non of the methods correct bias in standard deviation
- The best performance of QM and gnG in JJA but with larger IQR

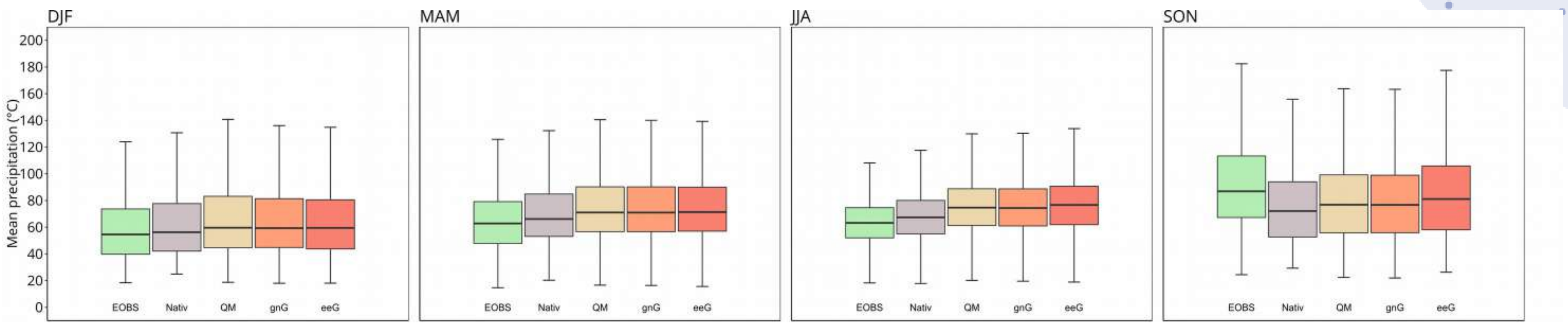
Results – temperature SKEWNESS



- Bias in skewness is positive only in autumn
- Native model intequartile range is smaller than in measurements
- QM (and gnG) only during spring improve skewness
- In winter and in summer eeG corrects skewness

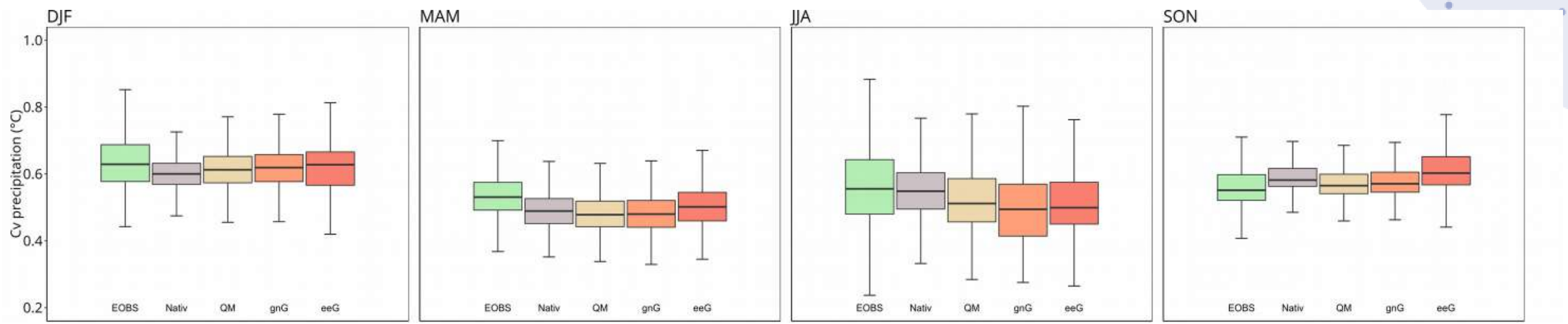
- Differences in sign of skewness in measurements and model simulations imply different temperature distributions
- During summer and winter temperature distributions from ensemble are leaned to the higher values while in the SON season, to lower values

Results – precipitation MEAN



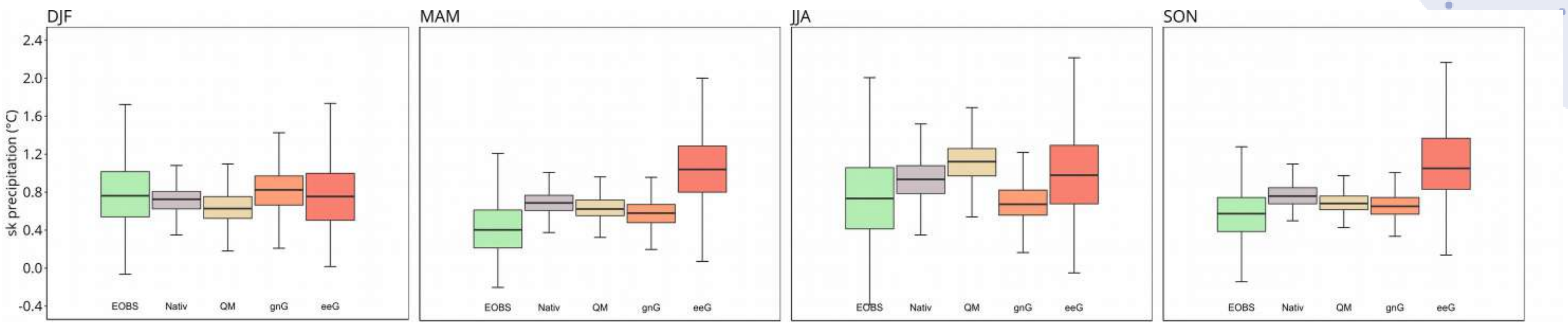
- Precipitation mean from ensemble in almost all seasons close (wet bias) to measurements
- Only SON precipitation mean from model simulations has dry bias
- In winter and autumn, the best correction at considered domain does eeG method
- During spring and summer, all methods enlarge bias

Results – precipitation COEFFICIENT OF VARIATION



- Coefficient of variation from ensemble – smaller IQR in winter and summer
- In intermediate seasons (especially in spring) IQR from ensemble close to measurements IQR
- eeG method in winter and spring performs better than other two methods
- During summer all methods enlarge bias
- In autumn, QM and gnG correct bias in coefficient of variation

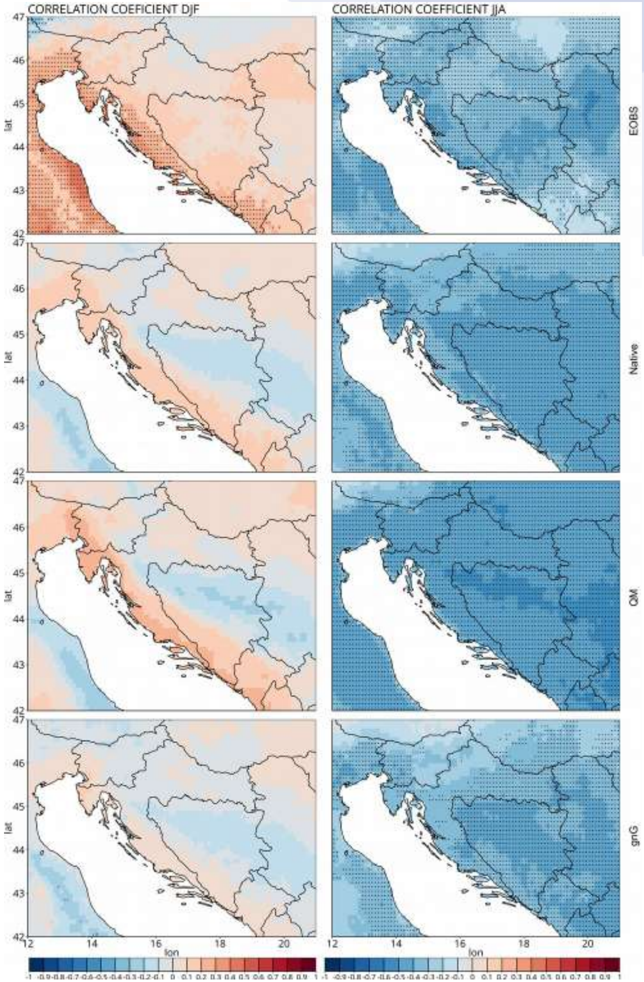
Results – precipitation SKEWNESS



- Skewness from ensemble data deviates from measurements in all seasons, IQR smaller
- The best performance in correcting the median of all data points has gnG method but it does not correct IQR
- In winter and summer eeG method corrects also the IQR while in intermediate seasons it even enlarges bias
- Univariate method (QM) in intermediate seasons corrects bias, but in summer and winter QM enlarges bias

Results – correlation coefficient

- What correction methods do to correlation between precipitation and temperature?
- Winter
  - Correlation positive along the eastern Adriatic coast
  - Connection not strong but significant (EOBS)
  - Univariate correction preserves correlation from ensemble and amplifies it
- Summer
  - More clear correlation in EOBS and ensemble data
  - As for summer, QM method amplifies correlation
  - gnG method except significance of correlation, corrects also the magnitude



Conclusion 1/2

- Bias and correction at all grid points of the considered domain
- Bias differs by season and by statistical measure
- Biases in measures of location (mean) and dispersion (standard deviation and coefficient of variation) are low
- Skewness in both variables has large bias
- Performance of methods differs according the seasons and statistical measures
- Temperature
    - Mean and standard deviation corrected with all methods → small corrections
    - In intermediate seasons skewness is not corrected
    - Differences in sign of skewness – distribution leaned on the other side

Conclusion 2/2

- Precipitation
  - Mean corrected in DJF and SON (eeG)
  - Convective precipitation during spring and summer – bias enlarged
  - In intermediate seasons skewness is not corrected
  - eeG method in DJF and JJA corrects interquartile range but gnG method corrects the spatial median of skewness
- Interquartile range rarely corrected
- Correlation coefficient
  - Univariate methods preserve correlation between precipitation and temperature from native ensemble
  - Bivariate methods correct correlation and preserve correlation between precipitation and temperature from E-OBS data
- **Tailoring bias correction method according to users needs**
- Manuscript in preparation

Thank you for your attention!

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VitaClim
Hrvatski šumarski institut